Name:

BE.011/2772J
Spring 2004
QUIZ III

You have 1 hour for this exam.

CLOSED BOOK
3 pages notes allowed

1 (45 points)	
2 (30 points)	
3 (25 points)	
total (100 points)	

Some formulas, constants, and conversions you may need:

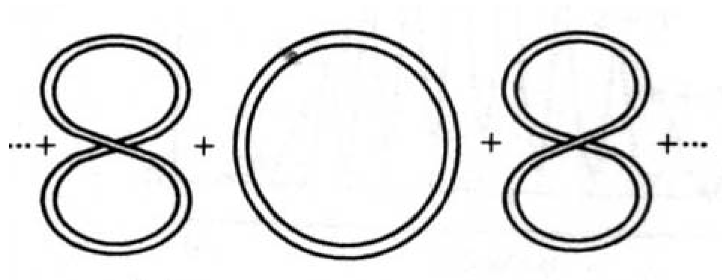
$k = 1.38 \times 10^{-23}$ J/K
$N_A = 6.02 \times 10^{23}$
0°C = 273K

Continued on next page....

Name:

1.) **DNA supercoiling**

We saw that circular DNA plasmids can supercoil into right or left handed supercoils with τ number of turns:



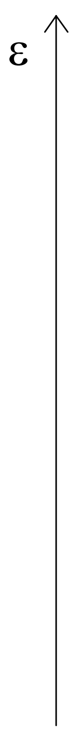
τ=-1 $\qquad$ $\tau = 0$ $\qquad$ $\tau = 1$

The energy in which it has τ turns is

$$\varepsilon = \tau^2 B$$

where B is a constant.

a) (10 pts) Draw the first few energy levels. Label the levels with their values of τ, and draw the energy levels to scale as much as possible (or label with its value of ε). Include degeneracies.



Name:

b) (2 pts) What are the units of B?

c) (18 pts) If T = B/k, what is the population of each of the energy levels at equilibrium? Which microstates are relevant (i.e., populated?). Levels which have less than 1% of the population can be considered negligible. Make a plot of population vs. energy justifying this.

Continued on next page....

Name:

d) (5 pts) Calculate average energy per plasmid, $\langle\varepsilon\rangle$ at $T = B/k$. Use the same cutoff as you did in part c. Leave in terms of B.

e) (5 pts) AFM is a technique which images the supercoils of DNA on a surface. It can distinguish the molecules from one another. Let's say we have 100 of these plasmids at a temperature of $T = B/k$. Calculate the entropy per plasmid.

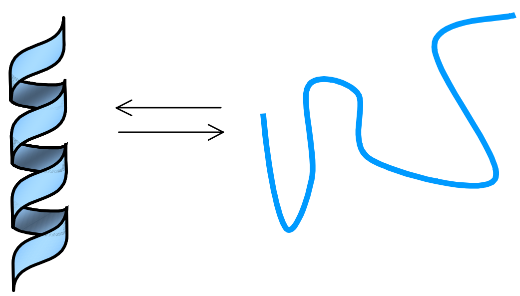
Name:

f) (5 pts) Calculate the free energy F of the entire system. Use the truncated form of the partition function you obtained in part c). Leave your answer in units of B.

2.) **Protein folding**

A 99 residue protein has only one folded α-helical conformation.

a) (10 pts) For the reaction



α helix random coil

Calculate ΔS assuming that each residue can have three different configurations. Is ΔS >, <, or = 0? Does this make sense? Why?

Name:

b) (10 pts) What is ΔH required for melting point to be 50°C? The melting point is defined as when the equilibrium constant is equal to 1.

c) (10 pts) Suppose you do an experiment on a solution of this protein and find ΔS<0. Does this concur with what you found in part a)? Why do you think this is?

3.) (25 pts) **Protein dimerization equilibrium**

You are interested in the tendency of a certain protein to form dimers. You obtain data for the equilibrium between monomer and dimer at 20°C and °30C and then your equipment breaks. Predict the equilibrium constant at 37°C if you found that the values of K at 20C and 30 C were $K_{20} = 18{,}000M^{-1}$ and $K_{30} = 20{,}000M^{-1}$.